GEOCHEMICAL SYSTEMATICS IN MANTLE MEGACRYSTS AND THEIR HOST BASALTS FROM THE ARCHAEAN CRATON AND POST-ARCHAEAN MOBILE BELTS OF SCOTLAND.

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The origin of megacrysts in alkaline volcanic rocks continues to be a somewhat controversial topic as they can represent (a) polybaric fractionates formed in conduits within the lower lithosphere, or (b) fragments of the peridotite protolith that comprises most of the lower lithosphere, or (c) shallow precipitates formed within crustal magma chambers. In an attempt to address these questions we have studied several on-craton and off-craton xenolith-bearing vents in NW Scotland. In particular mica, clinopyroxene and amphibole megacrysts entrained by Tertiary and Permo-Carboniferous alkaline volcanic rocks on and off the Hebridean craton were analysed for Sr, Nd and Pb isotopes and relative abundances of Sr, Rb, U, Pb and the rare earth elements (REE).

ON-CRATON

At present only one xenolith locality at Loch Roag Lewis has been studied within the Hebridean craton.

Micas - Rb/Sr and U/Pb ratios in on-craton mica megacrysts are quite variable (Rb/Sr = 0.538-0.946; U/Pb = 0.068-0.078). Rare earth element abundances in mica megacrysts are characterised by an enrichment in the LREE over the HREE (e.g. $(Ce/Yb)_N$ = 38.68-56.35) consistent with what is observed in mica megacryst data from other on-craton and off-craton localities. However no europium anomalies were found as reported by Menzies et al. (1985) for mica megacrysts from off-craton localities in southern Arizona. In the on-craton mica megacrysts $^{87}Sr/^{86}Sr$ = 0.70505-0.70773 [$(^{87}Sr/^{86}Sr)_{47Ma.}$ = 0.70395-0.70628] and extends the reported range for this locality and new $^{143}Nd/^{144}Nd$ data (0.51085-0.51233) overlap with previously published mica analyses (Menzies and Halliday 1988). The Pb isotopic variability is tightly constrained and overlaps with the field of EM1 (i.e.Enriched Mantle 1) apart from one data point which has anomalously low $^{207}Pb/^{204}Pb$ and high $^{208}Pb/^{204}Pb$ ratios. More importantly this mica megacryst has the lowest $^{143}Nd/^{144}Nd$ ratio ($epsilon_{Nd}$ = -34.2)reported for mica megacrysts from throughout the world .

Clinopyroxenes - Rb/Sr in on-craton clinopyroxenes are similar (Rb/Sr = 0.0031-0.0003) to that reported for other megacrysts but much higher than that reported for peridotite orogenic massifs or xenoliths. U/Pb in clinopyroxenes are similar (U/Pb = 0.065-1.120) to megacrysts from South Africa (on-craton) and the western USA (off-craton) (BenOthman et al,1990). REE abundances in clinopyroxenes define an inverted U shaped pattern comparable to megacrysts from South Africa and the western U.S.A. (Eggler et al 1989; Shimizu 1975). Overall the chondrite normalised rare earth abundance pattern is enriched in the LREE [e.g. on-craton cpx $(Ce/Yb)_N$ = 8.247-8.391].

On-craton clinopyroxene megacrysts have lower $^{87}Sr/^{86}Sr$ ratios than the micas (i.e. $^{87}Sr/^{86}Sr$ = 0.7046-0.7049) and Nd isotope data are more radiogenic than the micas ($^{143}Nd/^{144}Nd$ = 0.512447). Pb isotopic variability ($^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$) is tightly constrained within the EM1 field and as such the clinopyroxene and mica data overlap.

OFF-CRATON

Within the Proterozoic mobile belt of NW Britain several widespread localities were studied in order to assess the lateral (and vertical) variability of the post-Archaean lithosphere and to compare and contrast the origin of megacrysts within lithosphere of different ages (i.e. Dunaskin Glen, Kiers Hill, Elie Ness, Colonsay).

Micas - Rare earth element abundances in mica megacrysts are characterised by a LREE enriched pattern similar to on-craton micas (e.g. Ce_N/Yb_N = 5.837-19.041). These data are also similar to what is observed in mica megacrysts from other off-craton localities in eastern Australia and the western USA (Irving and Frey 1984; Menzies et al 1985). Off-craton mica megacrysts have $^{87}Sr/^{86}Sr$ = 0.74928-0.70669 [($^{87}Sr/^{86}Sr)_{280Ma.}$ = 0.70540-0.706290] and the $^{143}Nd/^{144}Nd$ = 0.51259-0.51267 and overlap with previously published mica megacryst analyses for off-craton localities.

Clinopyroxenes - In clinopyroxene megacrysts Rb/Sr = 0.0004-0.0158 and U/Pb ratios = 0.049-0.123. These ratios are *significantly lower* than that reported for pyroxene megacrysts from off-craton localities within the Proterozoic mobile belts of the western USA (U/Pb = 0.216-1.929; BenOthman et al,1990). REE abundances in clinopyroxenes define an inverted U shaped pattern comparable to megacrysts from on-craton and off-craton localities. Clinopyroxene megacrysts have $^{87}Sr/^{86}Sr$ = 0.70344-0.70589 [($^{87}Sr/^{86}Sr)_{280Ma.}$ = 0.70344-0.70571] and $^{143}Nd/^{144}Nd$ ratios = 0.51269-0.51275. These data overlap with the range reported for MORB and OIB. Pb isotope data are similar to that reported for other off-craton localities in the western USA and eastern Australia (BenOthman et al 1990, Stolz and Davies 1988).

MEGACRYST ORIGIN

On-craton megacrysts - Hypothetical liquids that may have co-existed with the megacrysts can be calculated using published partition coefficients and the elemental data outlined above. The calculated melts are very enriched in the LREE ($[Ce/Yb]_N$ = 50-70) and are similar to carbonatitic melts (Bell 1989) and pyroxenite xenoliths (Menzies and Halliday 1988). Any suggestion of a relationship between the megacrysts and melts similar to the host basalts can be further tested by comparison of the age corrected isotopic data for the megacrysts with the source characteristics of the host basalts. The on-craton micas and clinopyroxenes have ($^{87}Sr/^{86}Sr)_{47Ma.}$ = 0.70395-0.70628 which is comparable to that observed in ocean island basalts (OIB's) but the range in ($^{143}Nd/^{144}Nd)_{47Ma}$ = 0.51082-0.51241 is beyond that normally associated with OIB's. As a consequence of this we can conclude that it is rather unlikely that the bulk of the on-craton megacrysts represent polybaric fractionates from uncontaminated melts whose source region was similar to that of OIB (i.e. asthenosphere or deeper).

Perhaps the on-craton megacrysts are entrained fragments of the peridotite protolith. The Loch Roag Archaean? peridotite protolith appears to be similar to that normally encountered beneath mobile belts and not cratons. This is somewhat anomalous in that an integration of kimberlite-borne and basalt-borne xenolith data from on-craton (Archaean) and off-craton (post-Archaean) localities indicates that the Archaean peridotite protolith is normally highly magnesian and very different from that occurring beneath post-Archaean crust. This has been interpreted to mean that the Archaean protolith is a residue from extraction of komatiitic melts whereas the post-Archaean lithosphere represents a basalt residue. It appears that Loch Roag may be an exception to this rule if we can assume that lateral displacement has not occurred and resulted in the superposition of Archaean upper (crust) and post-Archaean lower (mantle) lithosphere. With regard to the origin of megacrysts we can state that the dominant mineralogy of the peridotite protolith is anhydrous and this makes it a rather unlikely source for hydrous megacrysts. Moreover the REE characteristics of the on-craton clinopyroxene megacrysts differ from that of clinopyroxenes in basalt-borne and kimberlite-borne peridotite xenoliths (Menzies and Hawkesworth 1987 and references therein; Nixon 1987 and references therein).

However one aspect of the megacryst data may link them to present-day enriched lower lithosphere. Pb isotope variations observed in on-craton clinopyroxene and mica megacrysts overlap with that of on-craton enriched spinel lherzolites from Loch Roag (i.e. EM1). This implies a possible co-genetic relationship since the Sr and Nd isotopic data also plot below the mantle array beyond the field occupied by OIB's toward EM1.

The similarity between hypothetical co-existing melts for the on-craton megacrysts and small volume carbonatitic melts and pyroxenite xenoliths from Loch Roag indicates that perhaps the on-craton megacrysts and pyroxenites represent disrupted conduits which formed from the migration and crystallisation of *lithospheric melts*. It is interesting to speculate that perhaps the spread of Sr and Nd isotopic data between OIB and EM1 indicates that a sub-lithospheric component (OIB) in some way triggered melting of the lithosphere (EM1) resulting in hybrid melt products which crystallised within the lithosphere. Eventual disruption and entrainment of this vein/wall rock assemblage would seem to account for the xenolith population, i.e. hydrous and anhydrous megacrysts, hydrous and anhydrous pyroxenites and enriched lherzolites (i.e. reacted wall rock adjacent to veins).

Off-craton megacrysts - Hypothetical melts that may have co-existed with the off-craton megacrysts are less enriched in the LREE ($[Ce/Yb]_N$ = 7-20) than those calculated for on-craton megacrysts being more similar to alkaline basalts. Moreover the off-craton micas and clinopyroxenes have $(^{87}Sr/^{86}Sr)_{280Ma.}$ = 0.70344-0.70629 and $(^{143}Nd/^{144}Nd)_{47Ma}$ = 0.51259-0.51275 which overlaps with the range observed in OIB's and as such differs from the on-craton megacrysts. We can conclude from these data that the off-craton megacrysts may represent polybaric fractionates of *asthenospheric melts* derived from source(s) similar to that of OIB's.

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